# Technical Progress and Social Development

By KARL T. COMPTON
FELLOW AIEE

**Technology has made enormous contributions to modern society, but there still remain many attention-challenging aspects of its influence upon social development; some of these aspects are discussed here by this noted scientist-educator, who says that many future social developments can be realized only through better technical developments and better management. The type of management that is most likely to be successful in the long run will direct and inspire, but not too rigidly control.**

THAT our national health, prosperity, and pleasure largely depend upon science for their maintenance and their future improvement, no informed person would deny. This opening sentence in the 1935 report of the Science Advisory Board epitomizes the judgment of that body of fifteen prominent scientists, engineers, and medical experts on the present-day influence of technical progress upon social development. It is not only scientists who hold this view. Nineteen years ago the American Federation of Labor expressed the same conviction in the following resolution:

> Whereas, the increased productivity of industry resulting from scientific research is a most potent factor in the ever increasing struggle of the workers to raise their standards of living, and the importance of this factor must steadily increase since there is a limit beyond which the average standard of living of the whole population cannot progress by the usual methods of readjustment, which limit can only be raised by research and the results of research in industry:
>
> Resolved, by the American Federation of Labor in convention assembled, that a broad program of scientific and technical research is of major importance to the national welfare . . .

Facts in support of this thesis are overpowering. Eighteen of the new industries which have grown directly out of scientific research within the past 50 years provide one-fourth of all the employment in the United States. The majority of the products now manufactured by electrical companies were unknown 15 years ago. It is estimated that 95 per cent of our chemical industry is based on fundamental discoveries made in university laboratories. A report of the Brookings Institution outlines the basic procedure necessary for economic recovery as the application of scientific methods to improve quality and decrease cost of production and to develop new products. It says that the basic necessity is to encourage science, encourage capital, and remove the artificial restrictions of regulations. Even in agriculture, perhaps the oldest of man's arts, technology has created new markets by developing transportation and storage facilities, has met the threats of food shortage for expanding populations by technical improvements in soils, seeds, and farming methods, and is seeking to develop new industrial uses for farm products in order to use the surplus which can now be produced.

We may accept the fact that technology has created enormous employment and wealth, has vastly increased opportunity, and has greatly reduced the hazards of sickness, famine, and suffering. If all this be granted, however, there still remain many aspects of the influence of technical progress upon social development which challenge attention. Four of these aspects are discussed briefly in the following paragraphs.

## 1. The Bogy of Technological Unemployment

In recent years much discussion has centered around technological unemployment—the loss of work due to obsolescence of an industry or use of machines to replace workmen or increase their per capita production. Are machines the genii which spring from the Aladdin's lamp of science to supply every need and desire of man, or are they Frankenstein monsters which will destroy man who created them? Startling examples of both viewpoints can be given.

If we look at industry *as a whole*, without inquiring into particular cases, we would conclude that technological unemployment is a myth, because statistics show no decrease in the fraction of our population gainfully employed during the last few generations in which machine production has become important. This is because technology has created so many new industries and has so greatly increased the market for many commodities by lowering the cost of production to make a price within reach of large masses of purchasers.

In individual instances, however, technological unemployment may be a very serious social problem, as in a town whose mill has had to shut down, or in a craft which has been superseded by a new art. Here the fact that technological unemployment does not exist as measured by over-all statistics is of small comfort to the families whose wage earners have lost their jobs.

Prepared especially for ELECTRICAL ENGINEERING, embracing the essential substance of a paper presented at the Seventh International Management Congress, Washington, D. C., September 19–23, 1938.

KARL T. COMPTON is president of the Massachusetts Institute of Technology, Cambridge. He was born at Wooster, Ohio, in 1887, and received the degrees of bachelor of philosophy (1908) and master of science (1909) from Wooster College, and doctor of philosophy from Princeton University in 1912. He has received the honorary degrees of doctor of science, doctor of engineering, and doctor of laws from several institutions. He began his career in educational work as instructor in chemistry at Wooster in 1909. In 1913 he was appointed instructor in physics at Reed College, and from 1915 to 1930, he successively held the following positions at Princeton University: assistant professor of physics 1915–19; professor of physics 1919–30; research professor and chairman of the department of physics 1929–30. He has been president of Massachusetts Institute of Technology since 1930. He is a member of many technical societies, and has served as president of the American Physical Society (1927–29) and of the American Association for the Advancement of Science (1935–36). Since 1932, he has been chairman of the committee on engineering schools of the Engineers' Council for Professional Development, which committee has been engaged in a program of accrediting engineering schools (*EE, Dec. '38, p. 513–16*). He has written and lectured widely on scientific and electrical subjects, and in 1931 he was awarded the Rumford Medal of the American Academy of Arts and Sciences for his contributions to the fields of spectroscopy and thermionic emission.

I believe that two principles should guide us in these matters. Improved products and services should be made available to the public, and not forcibly estopped to protect any entrenched business or any group of workers who would be thrown out of jobs by the change, but with this proviso: The change should be made in a manner to afford generous protection to the workers affected by it. This is a definite job for management, in which efficiency should be tempered by humane considerations (an attitude which, I believe, makes for real efficiency in the long run).

Various methods are available for reducing the shock of technological changes, such as retraining workers, gradual changeover to fit the normal turnover of personnel (as followed by the telephone companies in introducing automatic switching), pensions and unemployment insurance, efficient employment agencies for labor exchange, and co-operation between industries of a community to synchronize layoffs in one company with new employment in another.

In any case, I believe that the fundamental criterion for good management in this matter, as in every other, is that the predominant motive must not be quick profits, but best ultimate service to the public.

## 2. Technological Progess and Culture

In discussing the influence of technical progress upon social development there is a natural tendency to emphasize only the material products of technology, forgetting that social development is more an intellectual and spiritual than a material process, and overlooking the influence of technology on the cultural aspects of society. What, therefore, is the cultural influence of technology?

The first point which strikes one, in a long range view, is that man's achievement in every age has been made possible by, and limited by, the tools at his disposal. These limitations, in fact, are recognized in the names attached to the various stages of civilization, such as the Stone Age, the Bronze Age, or the Age of Steel.

The second significant fact is that technical progress has created opportunities for cultural development, by affording the necessary time and facilities. In the ancient "golden eras" when art, literature, law, and philosophy made great advances, these were possible because the Egyptians, Greeks, or Romans possessed slaves or, in the Renaissance of Europe, serfs, who performed the menial tasks and produced the wealth which gave time and energy for intellectual and artistic pursuits to a fortunate few. Granting the intellectual greatness of Aristotle, his achievements were certainly enhanced by his freedom from ordinary work and by the services of 10,000 research assistants, put at his disposal by King Alexander to bring him information of all sorts from all parts of the world.

In our day and generation, machines and mechanical power have taken the place of slaves in producing that large per-capita productive power which makes possible time and money for education, recreation, pensions, short hours of labor, literature and news from all parts of the world, and travel. In the United States the mechanical power used is equivalent to an average of the full time work of 50 slaves for each person.

Thus technical progress has afforded opportunities for cultural improvement. To some extent these opportunities have been utilized advantageously. We wish they were utilized better, and this, again, is a challenge to management, as well as to education and religion.

## 3. The New Demands on Technology

A survey of present-day social problems discloses some very definite directions in which technology can assist toward their solution. Some millions of people want work —respectable, creative, remunerative, permanent employment, and not temporary makeshift jobs or doles, or the dangerous device of producing war materials beyond reasonable requirements for defense.

All, including I believe the administrators of the great relief agencies, and with the only possible exception of a few selfish politicians, would like to see it possible for the government to withdraw from the business of unemployment relief through the creation of new employment in the regular channels of industry, agriculture, and commerce. The ideal goal is reduction of federal relief, as rapidly as regular employment can take up the slack, down to a minimum which will take care of unavoidable cases of technological unemployment in the transition period between jobs and will use this labor in the improvement of the public services and facilities for which the government is responsible.

Floods, droughts, dust storms, and encroaching soil erosion have focused attention on needs for safety and conservation on a very large scale. Acts of Congress and studies of the National Resources Committee attest the concern over problems of this type.

Without giving more examples, perhaps we can summarize by saying that the unemployed want work; industry wants profits; agriculture wants new uses for its products; national resources ought to be more wisely used; natural hazards should be curtailed; labor wants shorter hours and higher pay; all the people want more wealth, lower income taxes, better health and comfort, and additional facilities and commodities.

Every one of these desirable social developments can be realized only through the action of two forces: the force of better technical developments, and the force of better management. Better technical developments call for scientific and engineering research, training of research workers, adequate funds and facilities, and time. Better management, whether in business or in government, provides adequate attention to scientific research, and requires better understanding of problems, wiser formulation of policies, and greater efficiency in their execution. How to achieve such things is one of the greatest of all the problems facing management.

## 4. Principles of Management

The first of the general principles of management which seem to me to be fundamental is that management is an

essential attribute of decent group life. Without it there is chaos, discord, and ineffectiveness. Without it there is no security; and complete freedom from controls does not give liberty but rather the worst of all subjugations, anarchy without protection; but with management comes orderly procedure and directed co-operative effort so that the group becomes greater than the sum of the individuals which compose it. Undoubtedly the increasing complexities of modern life, due largely to technological progress, require a continually increasing degree and quality of group management.

The second principle is, at first glance, the antithesis of the first. It is that wise management involves the minimum of control and supervision consistent with reasonably smooth, co-ordinated and properly oriented operation. It is an evolutionary principle that, as individuals or groups grow in their ability to accept responsibility, the controls imposed on them are relaxed in order that they may accept and discharge responsibility. In this manner they develop their own powers and increase the contributions which they can make to their social group. This is a basic principle in training young animals and children, in training young executives, and in developing divisions of an organization.

The greatest of all management problems today is to determine the most advantageous balance between these two principles. How much management should be exercised and to what extent should it be centralized? The question arises in business and in government.

In industrial organization, in America at least, the pendulum is swinging definitely in the direction of less centralization of management, as well as of capital and of operating plant. The reason is that experience has shown too great centralization of control to be inefficient and also hazardous. The great desire of business now is to develop personnel that can wisely discharge responsibility and take initiative, rather than to depend upon an army of obedient hard-working, but unimaginative employees taking orders from the boss.

Large groups always evolve more slowly than small groups, so it is not strange that governments in many parts of the world today are rapidly moving in the direction of increasing the scope of management and its greater centralization, sometimes even into the hands of one individual. This was the trend of our industrial organizations two generations ago. A fair evaluation of this tendency in governments discloses that in many cases it has come about from natural causes, such as insoluble complications resulting from the Great War, or the previous relaxing of controls before a perplexed people had developed the power to accept the concomitant responsibilities, or for other reasons. As was the case in overdeveloped industries, the dangers in this movement in governments lie in such factors as present or future mismanagement on a large scale, disregard of the rights of other groups in the confidence and ambition of their present strength, failure to develop enough independent leadership within the group, inefficiency, and inability to secure any true evaluation of results or policies because of suppression of criticism.

The dangers confronting the less centralized democratic governments, on the other hand, are likely to be indecision in crises, inconsistency of policies, inefficiency in operations, and continual necessity of compromise between groups. We of democracies, however, believe that in the long run there is strength even in these apparent weaknesses, because they guard against rash actions, they develop the average intelligence and responsibility of the whole population and the whole setting encourages individual development and free enterprise. We find justification for our belief in the record of economic prosperity, high standard of living, and fundamental happiness of the people in those countries where democracy has been a spontaneous development from within, not imposed from without.

Some very important questions of management on a large scale are facing most of the people of the world today. Our brethren in some countries are putting their faith in the highly centralized management of dictatorships and authoritarian states. Our brethren in other countries, and we in America, have put our faith in a form of government definitely designed to serve and not to manage the citizens and to give maximum opportunity for free initiative and free expression. This situation offers a great opportunity to watch the results of the two sharply contrasting theories of management as an experiment on a colossal scale. God grant that our observation of this experiment be not interrupted by any action that will do irreparable damage to all people in both groups!

My final suggestion of a principle of management is the outgrowth of my contacts as a scientist. Experience has amply demonstrated a fact that, at first sight, seems surprising. It is that the most significant technological advances have not come out of direct efforts to make them, however well organized, but as unexpected by-products of scientific work undertaken for quite other objectives—usually for the satisfaction of scientific curiosity. Organized, directed effort is very effective in perfecting the details of a product or its production, but not in its initial discovery. This contrast is greater the more epoch-making is the new discovery.

The logical reason for this is not hard to understand. Really epoch-making discoveries are relatively unpredictable in advance. The practical solution to a difficult problem may come from any one of a multitude of directions. Really new ideas do not come to order, and are not pulled out of a hat. Who can tell in whose brain they will germinate? If an industrial research laboratory had been established a century ago to improve lamps, it would have investigated inflammable oils and gases, wicks, chimneys, and refractories. Not conceivably would it have paid attention to the leakage of electric charges through the air or to the behavior of magnets, wires, acids, and frogs' legs. Yet from these actually came the modern lighting devices.

I believe that the same logical and psychological principles operate in the field of management generally. A highly centralized and organized form of management may be very effective in performing the specific functions assigned to it in the manner stipulated by headquarters,

but it is not a favorable type of organization in which to take advantage of the potential genius inherent in the group which, if given opportunity, may produce better leadership and develop more advantageous objectives and more effective operations.

So I believe that experience, logic, and human psychology all support the view that that type of management is most likely to be successful in the long run which directs and inspires but does not too rigidly control, which offers large opportunity for initiative and for criticism, and which has faith in the mass judgment of an intelligent group and in the genius which may appear in unexpected quarters. Qualities like these are basic to the type of management which has found favor and success in this country, in the home, in business, and in the organization of our government itself.

## Test Barrel Devised for Surge Tests on Oils

INSULATION co-ordination on oil-circuit-breaker designs makes desirable a knowledge of surge voltages required to break down insulating oils. Because of the lack of available data on this subject a series of tests using hemispherical electrodes has been under way during the past year at the California Institute of Technology, Pasadena. One reason for the absence of data of this type, according to R. W. Sorensen (A'07, F'19) professor of electrical engineering at that institution, has been the difficulty in providing a convenient lead-in bushing for making the necessary tests. This difficulty was overcome by making a test barrel in which the electrodes were mounted, with a lead-in bushing of insulating material having about the same dielectric constant as insulating oil. Professor Sorensen has made available the following brief description of the test barrel.

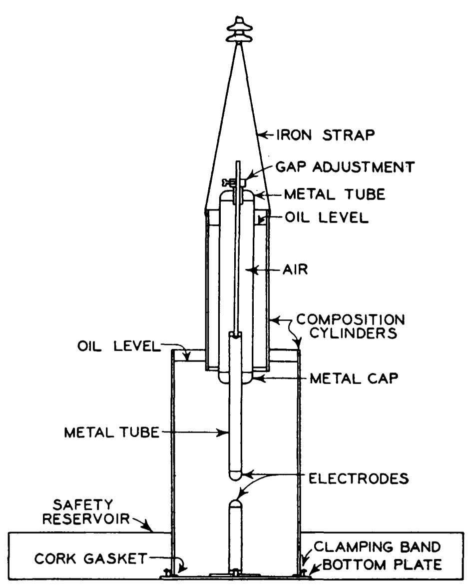
In making this device two composition cylinders made of paper and varnish were used. The larger cylinder, 40 inches in diameter and 72 inches long, forms the test chamber; the smaller one, 23 $^3/_4$ inches in diameter and 48 inches long, serves as a lead-in bushing. These cylinders were open at both ends when obtained. An oil-tight bottom for the test barrel was obtained by placing the insulating cylinder upon a steel plate on the surface of which a circular gasket seat had been machined. A cork gasket which could be clamped tightly between the end of the cylinder and the gasket seat was used. A steel clamping band, as shown in the accompanying diagram, drawn tightly around the larger cylinder by a bolt and drawn down hard upon the cork gasket by bolts through studs welded to the band and engaging threaded holes in the steel bottom, provided means for keeping this cork-gasket joint tight. Any oil leakage that might occur, due to accident or other cause, was amply provided for by placing the test barrel in a shallow oil-tight steel receptacle, large enough to hold all the oil used. With this arrangement, requiring only eight barrels of oil, the test electrodes are freer from field distortion due to adjacent materials than would be possible with the use of containers of metal or other conducting or even semi-conducting material, unless such containers were made very large. In other words, the use of oil in a barrel of insulating material having about the same dielectric constant as oil makes possible, with a small amount of oil, electric gaps immersed in what, in effect, is a column of oil insulation surrounded by the atmosphere of the test room.

Calculations before construction, and tests after construction, show that for all practical purposes this device provides a means of having test gaps in oil completely free from field distortion due to surrounding objects.

The cylinder serving as the lead-in bushing is closed at the lower end with a fiber and metal bottom designed to hold oil between it and a steel tubing concentric with the insulating cylinder and through which the upper and adjustable electrode extends into the test barrel. This metal part of the bottom is constructed in such a way as to provide for a well distributed electric field around the lower end of the bushing. The lower electrode supported by, and attached to, the bottom of the barrel was not made adjustable, but was constructed so as to be easily changed or removed for cleaning and polishing. During tests the part of the lead-in bushing between the outer and inner cylinders is kept filled with oil and flashover from lead-in conductor to the barrel is avoided by having its lower end project into the test barrel a few inches below the surface of the oil in the barrel. This arrangement proved entirely satisfactory as a means of limiting all arc-overs to the test gap.

All test electrodes used were round rods terminating as hemispheres having the same diameter as the rods. This type of electrode was chosen in preference to spheres mounted on rods or shanks, in order to avoid under-surge conditions and uncertainties regarding the influence of shank diameter upon the field uniformity around the gap, and, hence, upon the results obtained. Electrodes ranging from $^1/_4$ inch to 6 inches in diameter were prepared.

Initial results of tests made with the aid of this device are expected to be presented in a future AIEE paper.




**Cross section of test barrel and lead-in bushing**